PRESS RELEASE

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Subject line: **Uncovering the hidden history of a giant asteroid**

(Tokyo, June 11 2019) **A massive 'hit-and-run' collision profoundly impacted the evolutionary history of Vesta, the brightest asteroid visible from Earth. This finding, by a team of researchers from Tokyo Institute of Technology, Japan's National Institute of Polar Research and ETH Zürich, Switzerland, deepens our understanding of protoplanet formation more than 4.5 billion years ago, in the early infancy of the Solar System.**

Artist's concept of a massive 'hit-and-run' collision hitting Asteroid Vesta

In a remarkable feat of astronomical detective work, scientists have determined the precise timing of a large-scale collision on Vesta that helps explain the asteroid's lopsided shape. Their study, published in *Nature Geoscience*, pinpoints the collision to 4,525.4 million years ago.

Vesta, the second largest body in the asteroid belt, is of immense interest to scientists investigating the origin and formation of planets. Unlike most asteroids, it has kept its original, differentiated structure, meaning it has a crust, mantle and metallic core, much like Earth.

Most of what we know about the asteroid had so far come from howardite–eucrite–diogenite (HED) meteorites, following studies in the 1970s that first proposed Vesta as the parent body of these meteorites. In recent years, NASA's Dawn mission, which orbited Vesta in 2011–2012, reinforced the idea that HED meteorites originate from Vesta and provided more insights into the asteroid's composition and structure.

Careful mapping of Vesta's geology revealed an unusually thick crust at the asteroid's south pole.

The new study provides a confident framework for understanding Vesta's geological timeline, including the massive collision that caused the formation of the thick crust.

Key to uncovering this timeline was examining a rare mineral called zircon found in mesosiderites (stony-iron meteorites that are similar to HED meteorites in terms of texture and composition). Based on a strong premise that both types of meteorites came from the same parent body, Vesta, the team focused on dating zircon from mesosiderites with unprecedented precision.

Makiko Haba of Tokyo Institute of Technology (Tokyo Tech), a specialist in geochemical and chronological studies of meteorites, and Akira Yamaguchi of Japan's National Institute of Polar Research (NIPR) were involved in sample preparation — a major challenge, Haba explains, as fewer than ten zircon grains have been reported over the past few decades. "We developed how to find zircon in mesosiderites and eventually prepared enough grains for this study," she says.

Joining forces with co-authors at ETH Zürich who developed a technique to measure the age of the samples using uranium-lead dating, the team pooled their expertise to propose a new evolutionary model for Vesta. "This work could not be achieved without collaboration between Tokyo Tech, NIPR, and ETH Zürich," Haba points out.

The team highlights two significant time-points: initial crust formation 4,558.5 ± 2.1 million years ago and metal–silicate mixing by the hit-and-run collision at 4,525.39 ± 0.85 million years ago. This collision, impacting Vesta's northern hemisphere as shown in **Figure 1**, likely caused the thick crust observed by the Dawn mission, and supports the view that Vesta is the parent body of mesosiderites and HED meteorites.

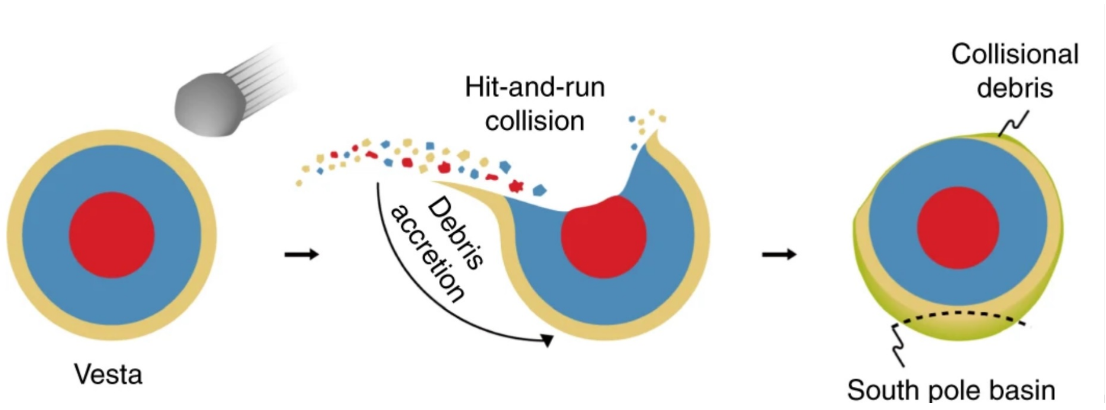

Figure 1. Representation of the hit-and-run asteroid collision
The proposed model describes a collision between Vesta, as the parent body of mesosiderites and HED meteorites, and a smaller planetesimal with a mass ratio of 0.1. The impact resulted in a major dent in Vesta's northern hemisphere, followed by

debris accretion in the southern hemisphere, accounting for the thick crust observed by NASA's Dawn mission.

By building on this study, Haba says she plans to examine "more precise conditions, such as temperature and cooling rate during and after the large-scale collision on Vesta based on mesosiderite and HED meteorite measurements."

"I'd like to draw a picture that shows the whole history of Vesta from the cradle to the grave," she says. "Combining such information with an impact simulation study would contribute to a more comprehensive understanding of large-scale collisions on protoplanets."

The dating method could be applied to other meteorites in future. Haba adds: "This is very important for understanding when and how protoplanets formed and grew to become planets like Earth. I'd like to also apply our dating method to samples from future spacecraft missions."

References

Makiko K. Haba[1,2,*], Jörn-Frederik Wotzlaw[1], Yi-Jen Lai[1,4], Akira Yamaguchi[3] and Maria Schönbächler[1]. Mesosiderite formation on asteroid 4 Vesta by a hit-and-run collision. *Nature Geoscience* (2019)

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